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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	徳山 喜一	審査員主査： Chief Examiner	三好 直人

要旨（英文 800 語程度）

Thesis Summary（approx.800 English Words ）

Stochastic geometry is the study of random spatial patterns. Such random structures have been recognized to play a key role in various fields such as cosmology, ecology, cell biology, engineering, and data sciences. One substantial essence in the field of stochastic geometry is the theory of spatial point processes, which are the tools to represent the random allocation of points in a certain given space. The spatial point processes have been applied to various contexts in the real world, for example, random arrivals of customers, distribution of Earthquake locations on the whole world.

This thesis studies applications of the stochastic geometry to the handover management problem in wireless cellular communication networks. Handover management has attracted attention of research in the context of wireless cellular communication networks. One crucial problem of handover management is to deal with increasing handovers experienced by mobile users. To address this problem, handover skipping techniques have been studied in recent years. For example, a fundamental handover skipping scheme, which we call alternate handover skipping, was introduced, where a moving user alternately performs handovers along its trajectory, thereby enabling the handover rate to be reduced to half. Another handover skipping scheme, called topology-aware handover skipping, was proposed, where the handover skipping is triggered according to the distance from the moving user and its target base station and the size of the cell. In this thesis, we propose yet another handover skipping scheme, called periodic handover skipping. In the proposed scheme, handovers of a mobile user are controlled by a certain fixed period of time, which we call skipping period. The skipping period can be managed as a system parameter, thereby enabling flexible operation of handover skipping.

We first investigate the periodic handover skipping scheme on a basic model of a single-tier cellular network, where base stations in the cellular network are deployed according to a homogeneous Poisson point process. Homogeneous Poisson point processes are often associated with point patterns that do not have any interaction between points. We then provide a tractable framework for analyzing the periodic handover skipping scheme. Under a random walk model of user mobility, we derive the analytical expressions of the two performance metrics, the handover rate and the expected downlink data rate. Moreover, by using these two metrics, we construct a utility metric representing transmission performance, regarding the trade-off relation between the handover rate and the data rate. Based on this utility metric, we conduct performance comparison between two scenarios where the periodic handover skipping scheme is introduced and not introduced.

We next study the optimal skipping period on the same single-tier cellular network model and consider maximizing the utility metric by controlling the skipping period introduced in the periodic handover skipping scheme. We numerically observed that there exists an optimal value of the skipping period, which locally maximizes the utility metric. We investigate the impact of other system parameters on the optimal skipping period. Moreover, we attempt to derive an approximate expression of the optimal skipping period. We also conduct numerical comparison with some other handover skipping techniques.

We further study the periodic handover skipping scheme on a two-tier cellular network based on a homogeneous Poisson point process and a Poisson-Poisson cluster process. Poisson-Poisson cluster processes are often used to model clustered nodes in a network, for example, small base stations deployed organically to complement the capacity of the cellular networks at user hotspots. Inside the network, we consider a random walk-based user with the periodic handover skipping technique. Based on the system model, we provide analytical results for the two performance metrics, the handover rate and the expected data rate, which are derived via the exact and the approximate analyses, respectively. In the numerical experiments, we found the values of the performance metrics behave differently compared to the case of the single-tier cellular network model. In addition, we conduct another numerical experiment to verify the efficiency of our proposed model in the two-tier cellular network.

We believe that our studies in this thesis could give some fundamental insights to the handover management problem. However, those studies still have various points that need extension. For example, we considered a deterministic length of the skipping period, which could be enhanced to the random skipping period. Although we focused on optimizing the performance of a single user, incorporating multiple users in this model is essential for capacity management and load balancing in cellular networks. For further study, we could consider incorporating the current wireless technologies in 5G, such as the inter-cell interference coordination, into the periodic handover skipping scheme. Moreover, this handover skipping scheme might contribute to the handover management problem in the unmanned aerial vehicle assisted cellular networks and the beam management problem in the millimeter-wave cellular networks.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

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